Art. XII.—*Victorian Graptolites: Part II. The Graptolites of the Lancefield Beds.*

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(With Plates XVII., XVIII., XIX.).

[Read 10th November, 1898].

The occurrence of graptolites at Lancefield was first recorded by myself some years ago when I described a species of Dictyonema from the locality.[1] Mr. G. B. Pritchard then followed with two papers on the graptolite fauna which will be subsequently referred to. The stratigraphical position was briefly dealt with by myself in a paper on the geology of Castlemaine, in which I showed that the Lancefield beds underlie the Bendigo series, or, as I there called it, the Tetragraptus fruticosus zone.[2] A further examination of the graptolites from the locality has strongly confirmed the views I then held, as an examination of the present paper will show.

The beds are very rich in individuals in a good state of preservation, and besides my own collection I have had the advantage of examining those of Messrs. G. Sweet, F.G.S., and G. B. Pritchard, and must acknowledge my thanks to them for placing their large series so unreservedly at my disposal.

The graptolites are preserved in an almost black, highly pyritous shale intercalated with fine grained intensely hard siliceous beds.

The only other fossils I have seen in the beds are sponge remains, a new species, Protospongia oblonga, being described in the present volume, and what appears to be a Lingulocaris allied to, if not identical with L. maccoyi Eth. jr.

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1 Proc. Roy. Soc. Vic., N.S. iv., 1892, p. 7.

2 *Ib.*, viii., 1894, p. 74.

All the specimens come from a small quarry a few hundred yards to the north of the now deserted Mount William railway station. There are at least three distinct bands containing fossils, but if any palaeontological differences exist between them they are very slight, and a collation of the species associated on a large number of slabs has yielded no definite results. This point must be insisted on, as otherwise, the association of the forms here dealt with, would, by European analogy, induce the opinion that several very distinct horizons were confused, which is certainly not the case.

Bryograptus, Lapworth, 1880.

Bryograptus victoriae, n.sp.

(Pl. XVII., Figs. 1, 2).

Branches diverging at first at about 50°, curving towards one another and again dividing at about 70° or 80°, forming a bell-shaped hydrosome. Sicula with a prolonged virgula of about 2 mm. in length. Thecae straight-sided, apertural margin at right angles to the branch, outer margin at an angle of about 10° or 12°; about 10 in 10 mm. Breadth of branches about 0·5 mm.

There is no evidence of overlapping of the thecae in any of the specimens I have seen.

The fine thread extending from the pointed end of the sicula is morphologically a virgula, and no useful purpose is served by applying a different name to it. Its presence has of course long been recognised in such forms as Didymograptus caduceus, though its true nature was long misunderstood.

Bryograptus clarki, n.sp.

(Pl. XVII., Figs. 3, 4).

Branches straight and inclined at an angle of about 135°, 0·5 mm. broad, giving off branches on their inner side near the sicula. These four branches again branch at a little more than 3 mm. from their point of origin. Sicula with a short virgula. Thecae about 10 in 10 mm., straight sided; apertural margin inclined at about 100° to the axis of the branch; outer margin

forming an angle of 20° with the same; free for one half their length and indenting the branch about one half its width.

I have much pleasure in dedicating this species to a former pupil, Mr. George Clark, who was the first to find graptolites in these, the oldest Australian graptolite beds yet discovered.

Leptograptus, Lapworth, 1873.

Leptograptus antiquus, n. sp.

(Pl. XVII., Figs. 5, 6).

Polypary of extreme tenuity. The two branches diverging at about 180° from the sicula, and slightly curving with the thecae on the concave side; these primary branches at times give off a secondary branch. Breadth of branches 0·1 mm. Thecæ 7 in 10 mm., not in contact with one another; apertural margin straight or, when compressed in a different manner, slightly concave; inclined to the axis at an angle of 90°; outer margin slightly concave and inclined at an angle of 30°. Breadth from tip of theca to back of branch about 0·4 mm.

Specimens giving off a secondary branch are not very common, forms with only two branches being of far more usual occurrence. The branching usually takes place in the neighbourhood of the sicula and I have seen a few with four branches produced in this way. In the example figured the branch is given off at a considerable distance from the sicula, it is well preserved and there is no doubt as to the branching really taking place as figured.

Owing to the great delicacy of the polypary specimens frequently occur in a somewhat tangled state, and in such examples the sicula and first and second thecae are often more clearly preserved than the rest of the specimen. The species is fairly common and is easily distinguished from Didymograptus pritchardi n. sp. with which it is associated and with which it is perhaps liable to be confused, by its more slender habit and by the much more distant thecae which do not overlap.

The genus has already been recorded from Lancefield by Mr. G. B. Pritchard.[1]

[1] Proc. Roy. Soc. Vic., N.S. vii., 1895, p. 30.

Didymograptus, McCoy, 1851.

Didymograptus pritchardi, n. sp.

(Pl. XVII., Figs. 7, 9; Pl. XIX., Figs. 8, 10).

Hydrosome very slender, the two branches at first forming an angle of about 140° with one another, then gently and evenly curving, with the concavity on the theca bearing side. Not infrequently a third branch is given off, from the neighbourhood of the second theca, while rarely another branch arises from a similar position on the other side of the sicula. Branches about 0·5 mm. wide, and may reach a length of over 12 cm. Thecae about 10 in 10 mm., very long and narrow, overlapping apparently about one half their length; apertural margin straight or slightly convex, at right angles to the branch. Outer margin at first making a very small angle with the branch, but towards the aperture becoming deeply concave and forming an acute point. Virgula at times extending for a considerable distance from the proximal end of the sicula.

This slender form is fairly common and almost always has but two branches developed, so that I have ventured to refer it to Didymograptus. Had the four branched forms been at all common, instead of rare, they might have been regarded as the normal ones, and those with two or three branches as having arisen by the suppression of one or more branches. The exceedingly narrow proximal part of the thecae led me at first to think that no overlap took place, and that the form was a Leptograptid, but that the thecae do overlap is clear from the examination of a specimen preserved partly in relief. The virgula is at times visible as an exceedingly fine thread and may reach the length of 4 mm.

Didymograptus taylori, n. sp.

(Pl. XVII., Figs. 11, 12).

Branches diverging at an angle of from 140° to 160°, straight, 0·5 mm. broad near their origin and gradually increasing to 0·75 mm. at their distal end, each from about 5 to 10 mm. long. Sicula about 1·5 mm. long. Virgula extending for some 3 or 4

mm. and scarcely visible except under the lens. Thecae 11 or 12 in 10 mm. slightly expanding towards the aperture, overlapping for one half their length, two and a half times as long as broad; apertural margin slightly concave, inclined at an angle of about 80° to the axis, so that the aperture looks slightly inwards; outer margin gently concave and inclined at an angle of 25°.

In one case the virgula, at a distance of 4 mm. from the sicula, appears to terminate in a pear-shaped vesicle about 0.7 mm. in length, being attached to its smaller end. As, however, the virgula is not exposed the whole way, the connection is not certain and my attempts to clear it have not been successful.

Named as a tribute to the memory of the late Norman Taylor of the Victorian Geological Survey.

Tetragraptus, Salter, 1863.

Tetragraptus decipiens, n. sp.

(Pl. XVII., Figs. 13–15; Pl. XVIII., Figs. 16–19).

Tetragraptus quadribrachiatus, Pritchard (*non* J. Hall). Proc. Roy. Soc. Vic., N.S. vii., 1895, p. 30.

Form stout, branches arising close to the sicula, apparently from the second and third thecae, and from 0·5 to 1 mm. broad. Thecae slightly expanding, overlapping for about one half their length; apertural margin concave, set at an angle of from 95° to 100° to the axis of the branch; outer margin with a slight concave curvative which gently increases near the aperture; inclined at first at an angle of about 10° to the branch and near the aperture of about 30°. Virgula shown as a fine line, often about 7 mm. in length.

Figures are given showing the apparent variation produced by the polypary being embedded in different positions. Fig. 13, which represents a common method of preservation of young specimens, shows that the angle of divergence of the branches is less than 180°. With increase in size this position becomes less common, and a regular cross is displayed. In this latter case the thecae and sicula are naturally not well shown and the likeness to similarly preserved specimens of T. quadribrachiatus

is pronounced. Numerous examples occur connecting these two extremes, and there can be but little doubt of their identity, though at first sight they seem sufficiently distinct. The presence of the prolonged virgula, the much narrower thecae, and their smaller angle of inclination to the axis of the branch sufficiently distinguish this species from T. quadribrachiatus.

Clonograptus, Nicholson, 1873.

Clongraptus flexilis, J. Hall.

(Pl. XIX., Fig. 20).

Graptolithus flexilis, J. Hall. Geol. Surv. Canada. Rep. for 1857, p. 119. *Id.* Grap. Quebec Group, 1865, p. 103, pl. x., f. 3-9. Wdct. 8, p. ii.

Hydrosome bilaterally symmetrical, copiously branching. Branches of the first order in the same straight line; those of the second order diverging at an angle of about 100°; those of the third order vary so much that measurements are of no value, a range of from 50° to 100° having been observed. Branches of a still higher order seem to diverge at a fairly constant angle of between 30° and 40°, slightly curving towards one another after the bifurcation. The width of the primary branches is a little more than 1 mm., and from this they gradually decrease in breadth till they become scarcely perceptible to the unaided eye. Fairly rigid at first, they become more flexible distally. Branches of the first order about 1 mm. long; of the second 4 mm.; of the third about 5 mm.; of the fourth about 8 mm.; the distance between bifurcations of a higher order increasing greatly but irregularly. Thecae not observed.

The occurrence of this species at Lancefield has already been recorded by Mr. G. B. Pritchard[1] and the figure is from one of his specimens, it being more distinct than any of my own. All the specimens I have seen, about a dozen altogether, are somewhat stouter in their proximal parts than Hall's description and plate of the Point Lévis specimens indicate, in this particular agreeing more closely with his woodcut[2] which has been reproduced by Nicholson.[3]

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1 Proc. Roy. Soc. Vic., N.S. vii., 1895, p. 30.

2 *L.c.*, p. 11; and Twentieth Report of the State Cabinet of N.Y., p. 176, f. 9.

3 Monogr. British Grap., f. 51, p. 108.

Clonograptus magnificus, Pritchard.

Temnograptus magnificus, Pritchard. Proc. Roy. Soc. Vic., N.S., iv., 1891, p. 58, pl. vi., figs. 1-3 ; *and* vol. viii., 1894, p. 29.

The gigantic size of the type specimen, about one metre in diameter, is very remarkable. Fragments are not uncommon at Lancefield, and I have seen a specimen, said to be from Bendigo, which I believe to be the same species.

Clonograptus rigidus, J. Hall.

(Pl. XVIII., Fig. 22; Pl. XIX., Fig. 21).

Graptolithus rigidus. Geol. Surv. Canada, Report for 1857, p. 121 ; *id.* Grap. Quebec Group, 1865, p. 105, pl. xi., figs. 1-5.

Branches numerous, of small diameter and fairly rigid becoming somewhat flexible towards their extremities. Primary branches from 1 to 1·5 mm. long and in a straight line; secondary branches 4, or rarely 5 mm. long, branching at an angle of from 90° to 120°; tertiary branches from 5 to 9 mm. long, forming at an angle of from 60° to 90° with each other. The subsequent branches diverge at an angle of about 30° or 40° and usually are but slightly flexible. In some cases however, probably from maceration, the whole hydrosome is so devoid of rigidity that the branches as far down as the tertiaries are much curved and tangled. The diameter of the branches is at first about 0·5 mm., and evenly and gradually diminishes towards their distal ends. Thecae 11 in 10 mm., slightly expanding; apertural margin perpendicular to the branch; outer margin slightly concave, inclined at about 15°.

Clonograptus rigidus, *var* tenellus, Linnarsson.

(Pl. XVIII., Figs. 23-25).

Dichograptus tenellus, Linnars. Ofv. kon. Vet. Ak. Förh., Ärg. 20, 1871, No. 6, p. 794, t. 16, figs. 13-15.

Clonograptus tenellus, Moberg. Sver. Geolog. Undersök. Afhandl. och. Upsatter. C., 125, p. 3, t. 1, f. 1-3, 1892.

Hydrosome slender, branches rigid, about 0·2 to 0·5 mm. broad. Sicula small, a virgula 1 mm. in length occasionally

visible. Primary branches in a straight line each about 1 mm. long. Secondary branches forming an angle of about 90° with each other, about 2 or 3 mm. long. Tertiary branches diverging at about 65°, and 4 or 5 mm. long. Those of the fourth order branching at 50°. Thecae narrow, apertural margin nearly at right angles to the branch; outer margin straight or slightly concave, inclined at an angle of about 10°; 10 or 11 present in 10 mm., and present on secondary and all succeeding branches, but not observed on the primary.

The above description is drawn up from specimens before me and agrees well with the very full one given by Moberg of the Swedish forms. Linnarsson in his original description gives 7-8 thecae as the number in 10 mm., as also does Frech,[1] who had well preserved specimens from the type locality. Moberg however gives 8-10 as the number in the same length, while the Lancefield specimen seem to have 11 pretty constantly.

If the specimens I have identified as C. rigidus and C. tenellus are correctly determined, and to my mind there is no doubt that they are, then there can be no reasonable ground for their specific separation. Were extreme forms alone considered their union under one specific title would be doubtful, but the occurrence of a large number of intermediate examples, which one hesitates to refer to either "species," compels us to unite the whole series under the name of the first described form, C. rigidus. The thecae of both C. rigidus and C. tenellus are similar in shape, about the same number occur in a given space in both forms, while the general appearance of the hydrosome differs only in the smaller build of Linnarsson's species and in its less copious branching. That this is subject to considerable variation the diagrams below will make clear. In drawing them up I have merely measured with dividers and a boxwood scale to the nearest half millimetre. The measurements in each case will be seen to be aggregated round one common mean, and not two, as would be the case if the length of the branches afforded a satisfactory means of separation. Each dot represents a single measurement.

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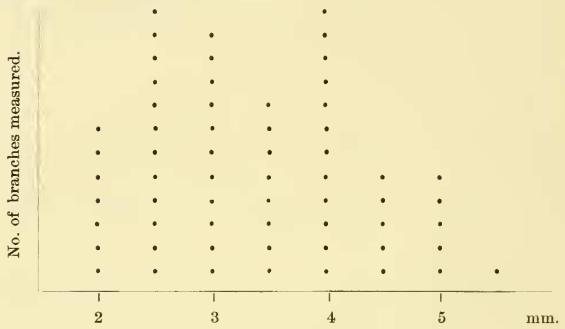
[1] Leth. Geog. 1Th. 1B., p. 598, 1897.

Diagram showing Lengths of Branches in C. rigidus and C. tenellus.

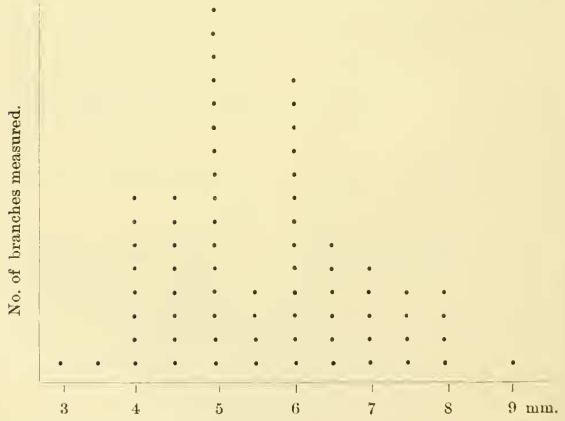
Branches of Second Order.

Number of Individual Specimens 17.



Branches of Third Order.

Number of Individual Specimens 12.



Comparing the measurements of Hall's figures in Grap. Quebec group, with Moberg's description we get the following (in mm.)

	1	2	3
C. rigidus.			
Hall	1 ($\frac{1}{20}$ in.)	3–8	5–10
Moberg	Branches twice the size of those of C. tenellus.		
C. tenellus.			
Moberg	2	4	

One peculiarity which is rather striking is the occurrence of specimens which are so delicate that they are mere phantoms, though associated with others which are well developed. At times a specimen will be fairly broad and distinct at the base and will fade away gradually towards the distal extremity of the branches, so that even with a lens one cannot be certain where the end is. In these examples, as in fact is usually the case, the thecae are embedded and no sicula is visible. Whether this tenuity is real, and due to an under-development of chitin, or whether again it is due to maceration are questions not easy of solution.

One specimen showed primary branches 1·2 mm. long; secondary 5, 5, 4, 4 mm. long; tertiary 6, 8, 7·5, 7·5, 7·5 mm.; diameter of the primary branches 0·5 mm., while the distal ends are so fine as to be scarcely visible. Usually however it is specimens of *var.* tenellus with secondaries from 2-3 mm. and tertiaries from 3-5 mm. long which are thus preserved.

Both varieties are fairly common and frequently preserved on the same slab.

Phyllograptus, J. Hall, 1857.

PHYLLOGRAPTUS ? sp.

(Pl. XVIII., Fig. 26).

I have seen a single specimen which I think is referable to this genus. It is partly covered and not in a good state of preservation, so that nothing but the outline can be made out. The fragment is 25 mm. long and the uncovered part is about 4 or 5 mm. broad. Thecae 10 or 11 in 10 mm., apertural margin

convex, outer margin slightly concave. Attempts made to clear the specimen not being successful I thought it advisable not to endanger it. I have very little doubt that the generic reference is correct, though the occurrence of the form in the Lancefield rocks must be very rare. The specimen was collected by Mr. G. Sweet.

Dictyonema, J. Hall, 1852.

Dictyonema macgillivrayi, T. S. Hall.

(Pl. XVIII., Fig. 27).

Dictyonema grande, T. S. Hall (*non* Nicholson). Proc. Roy. Soc. Vic., N.S. iv., 1892, p. 7, pl. i., ii.; *id.*, Pritchard, *Ib.*, vii., 1895, p. 28.

Dictyonema macgillivrayi, T. S. Hall. *Ib.*, x., 1897, p. 15.

The thecae have been described by Mr. Pritchard and owing to his kindness I am able to give a figure of them from his specimen. Fragments of the species are not uncommon.

Dictyonema pulchellum, n. sp.

(Pl. XVIII., Fig. 28-30).

Hydrosome circular, about 15 mm. in diameter; branching dichotomously from the base, at fairly regular intervals. Radial branches about 1 mm. broad. Connecting branches at right angles to these, about 1 mm. apart and about 0·2 mm. broad, expanding at the point of junction with the radial branches. Thecae with slightly concave apertural margin at right angles to the branch; outer margin straight, forming an angle of 25°-30° with the axis of the branch; probably about 7 in 10 mm.

This pretty little form is represented by four examples in the collection of Mr. G. B. Pritchard, and are all on one small slab. One specimen has been compressed laterally, so that the hydrosome was apparently cup shaped, and in this example the thecae are visible near the base. In none of the other examples can I detect any signs of thecae which are most likely embedded at right angles to the bedding plane.

The following is a list of the species obtained :—

Bryograptus victoriae, n. sp.
Bryograptus clarki, n. sp.
Leptograptus antiquus, n. sp.
Didymograptus pritchardi, n. sp.
Didmograptus taylori, n. sp.
Tetragraptus decipiens, n, sp.
Clonograptus flexilis, J. Hall.
Clonograptus magnificus, Pritchard.
Clonograptus rigidus, J. Hall.
., ,, *var* tenellus, Linnars.
Phyllograptus ? sp.
Dictyonema macgillivrayi, T. S. Hall.
Dictyonema pulchellum, n. sp.

In examining the above list we are confronted by the fact that two of the genera, namely Bryograptus and Leptograptus, are regarded as belonging to entirely different horizons, although here occurring on the same slabs. European geologists consider the former genus as indicative of Cambrian age, while Leptograptus is, according to Lapworth,[1] confined to the Upper Ordovician, although one section of the family Leptograptidae, as represented by Azygograptus, ranges as low as the base of the Arenig. The associated genera at Lancefield forbid us regarding the beds as younger than Lower Arenig, so that we must consider the genus Leptograptus as of greater age in Australia than in Europe. With regard to Bryograptus it is looked on by European geologists, as previously mentioned, as a Cambrian form, and Clonograptus tenellus is referred to the same age. Didymograptus, Tetragraptus, Clonograptus flexilis, C. rigidus, Phyllograptus and Dictyonema of the type herein recorded all occur in the Lower Arenig of Europe and some of the genera range higher.

The stratigraphical position of the American species Clonograptus rigidus and C. flexilis adds another difficulty, since an inspection of the list by Ami in the Report on the Geology of a Portion of the Province of Quebec by R. W. Ells[2] shows that

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[1] Ann. Mag. Nat. Hist., 5 S, vol. 6, p. 27.
[2] Ann. Rep. Geol. Surv. Canada for 1887-8, iii., K, p. 116.

C. flexilis is associated with forms most of which occur in our T. fruticosus zone at Bendigo, while C. rigidus is accompanied by Loganograptus logani which, in Victoria, does not appear till after Phyllograptus typus has become extinct.

There can be no doubt that the Lancefield beds are below the beds which I have elsewhere called the Tetragraptus fruticosus zone[1] where all the genera, except Dictyonema and perhaps Bryograptus occur.

As regards Dictyonema it is not a little remarkable, considering its range both in Europe and America, that not a single specimen has been recognised in Australia from anywhere except Lancefield.

The single specimen which I have doubtfully referred to Phyllograptus is the only one I have seen from the locality and is alone on a small slab.

The question then arises how far below the Bendigo series do the Lancefield beds lies? Are we, on the evidence of the presence of Bryograptus and of Clonograptus tenellus, to regard them as Cambrian, or are we to regard these forms as here ranging into the Ordovician? Owing to the occurrence of Bryograptus and Dictyonema sociale Lapworth has called the Cape Rosier zone of Canada Cambrian,[2] but Ells in the report above quoted, hesitates to follow him till more stratigraphical evidence is available. There is nothing apparently inherently improbable in the Cape Rosier zone being Cambrian, for the so called Quebec group, to which it belongs, and in the district where it occurs, comprises rocks varying in age from Pre-Cambrian to Silurian. With us there is an indication at any rate that the same state of things may possibly occur. Our palaeozoic rocks are remarkable for the persistence of their strike, which is not interrupted by the intervention of even large areas of intrusive granite. Thus the Chewton-Castlemaine Ordovician is interrupted to the north by the belt of Maldon-Elphinstone granite which is about ten miles wide, and yet to the north of the area we again get Ordovician rocks of the same age and the strike is unchanged, being still a few degrees west

[1] Proc. Roy. Soc. Vic., N.S. vii., 1894, p. 76.
[2] Trans. Roy. Soc. Canada, 1886, p.

of north. At Lancefield the rocks strike N. 15° W. and are cut off to the north by another granite area, that of the Baynton Range, while beyond this again palaeozoic rocks with the same strike occur. Now, if the line of strike of the Lancefield rocks be followed across the granite to Heathcote, a distance of thirty miles, we come to a locality yielding fossils considered by Mr. R. Etheridge, jr., as probably of Middle Cambrian age.[1]

It is true that no great weight can be attached to this fact in the way of supporting the Cambrian age of the Lancefield beds, though it points to the strong probability of the so called metamorphic rocks to the eastward of the graptolite beds at Lancefield being true Cambrian.

Taking all the facts into consideration I think that less violation will be done to generally accepted ideas by regarding Bryograptus as here ranging up into the Ordovician than by looking on the other genera as dating back to Cambrian times, and we are, I venture to think, justified in considering the graptolite bearing beds of Lancefield, which are dealt with in the present paper, as Ordovician rather than Cambrian.

EXPLANATION OF PLATES XVII., XVIII., AND XIX.

Fig. 1.—Bryograptus victoriae, n. sp., nat. size.
„ 2. „ „ same specimen × 3½.
„ 3.—Bryograptus clarki, n. sp., nat. size.
„ 4. „ „ same specimen × 5.
„ 5.—Leptograptus antiquus, n. sp., nat. size.
„ 6. „ „ same specimen × 5 (Coll. G. Sweet).
„ 7.—Didymograptus pritchardi, n. sp., nat. size.
„ 8. „ „ nat. size; showing 3 branches.
„ 9.—Didymograptus pritchardi, proximal part of No. 8 × 5.
„ 10. „ „ proximal part of another specimen showing virgula.
„ 11.—Didymograptus taylori, n. sp., nat. size.
„ 12. „ „ proximal part × 3.

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1 Proc. Roy. Soc. Vic., N.S., viii., 1896, p. 52.

Fig. 13.—Tetragraptus decipiens, n. sp., nat. size.
„ 14. „ „ „ „ „
„ 15. „ „ same specimen as 14 × $3\frac{1}{2}$.
„ 16. „ „ specimen with 6 branches, nat. size.
„ 17.—Tetragraptus decipiens, nat. size.
„ 18. „ „ „ „
„ 19. „ „ portion showing thecae × 5. (Figs. 17-19 Coll. G. B. Pritchard).
„ 20.—Clonograptus flexilis, J. Hall, × $\frac{1}{2}$ (Coll. G. B. Pritchard).
„ 21.—Clonograptus rigidus, J. Hall, nat. size (Coll. G. B. Pritchard).
„ 22.—Clonograptus rigidus, thecae × $3\frac{1}{2}$ (Coll. G. Sweet).
„ 23. „ „ *var* tenellus, Linnars., nat. size.
„ 24. „ „ „ „ „ „ „
„ 25. „ „ „ „ another specimen × $3\frac{1}{2}$.
„ 26.—Phyllograptus sp. (Coll. G. Sweet).
„ 27.—Dictyonema macgillivrayi, T. S. Hall, thecae enlarged, (Coll. G. B. Pritchard).
„ 28, 29.—Dictyonema pulchellum, n. sp., nat. size.
„ 30. „ „ portion of 29 enlarged, showing thecae.